Hospital Consolidation and Costs: Another Look at the Evidence

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Abstract: We investigate whether one-to-one hospital mergers lead to short-term cost savings. We use a unified empirical methodology, so that we may directly compare results for systems (where share ownership but maintain separate licenses) and mergers (where hospitals share the same license). Our comparison group consists of a group of ten 'pseudo mergers' that were chosen at random based on the hospital characteristics of the merged hospitals. Estimates of a multi-product cost function reveal that hospitals that form systems do not enjoy any measurable cost reductions. On the other hand, mergers that lead to closure (or conversion) of one of the inpatient facilities offer considerable savings – our point estimate is about -6 percent. The cost savings associated with these mergers increases to about -11 percent three and four years after the merger. However, mergers that do not lead to closures appear to increase costs in the short-run, by an estimated 4 to 5 percent. However, after three or four years, these mergers may contribute to about 5% reduction in costs, though the results are not significant. The results are robust to changes in the specification and the sample.

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Hospital Consolidation and Costs: Another Look at the Evidence

1. Introduction

The introduction of the Medicare Prospective Payment System in 1983, followed by the rapid growth of managed care among privately insured individuals, have placed enormous fiscal pressure on hospitals. Dranove et al. (2001) show that hospitals responded to this pressure by consolidating with local competitors. Hospital executives hope that consolidation generates efficiencies. But insurers fear that consolidation increases hospital market power and hospital prices without any offsetting cost reductions.

Thus far, the empirical evidence on consolidation efficiencies is mixed, and the research methods have been inconsistent. Two recent studies reach seemingly conflicting conclusions about consolidation. Dranove and Shanley (1995) and Dranove, Durkac and Shanley (1996) (henceforth DDS) report that costs in multihospital systems in California were similar to the costs of independent hospitals in the state. Using nationwide sample of hospitals that merged between 1986 and 1994, Connor, Feldman and Dowd (1997, 1998) (henceforth CFD) report that costs in merging hospitals declined relative to the costs of hospitals that did not merge.

In this paper, we investigate these findings using improved methods and up-to-date data. We describe fundamental distinctions between system acquisitions and mergers to explain why we might expect different results. At the same time, we use a unified empirical methodology, so that we may directly compare results for systems and mergers. Our methods attempt to address many problems overlooked in previous studies. Based on estimates of a multi-product cost function, we find that hospitals that form systems do not enjoy any measurable cost reductions two, three, or four years post-acquisition. On the other hand, mergers that lead to closure (or conversion) of one of the inpatient facilities offer considerable savings – our point estimate is about –6 percent. However, mergers that do not lead to closures appear to increase costs two years post-merger by an estimated 4 to 5 percent. Overall, our findings suggest that in the short-run hospital consolidation does not, in general, lead to significant cost reductions. However, three to four years after the merger, both merger then closures and mergers where one of the facilities remains open lead to cost reductions, though only the former savings are statistically significant.

2. Background and related research

Prior to the last decade, hospital consolidation usually involved acquisitions by national systems such as the Hospital Corporation of America and Humana. These national systems acquired hospitals scattered throughout the United States, so that they rarely achieved local consolidation efficiencies. In the last decade, hospitals began to consolidate with local competitors.[2] Local consolidation has taken two forms. In local multi-hospital systems (henceforth, "systems"), two or more hospitals in the same geographic market have common ownership, but maintain separate physical facilities, do business under separate licenses, and keep separate financial records. In local mergers (henceforth, "mergers") two or more hospitals in the same local market have common ownership, do business under a single license, report unified financial records, and possibly consolidate some physical facilities.

[2] Dranove et al. (forthcoming) show that this consolidation was largely a response to the growth of managed care.

Whether forming systems or merging, consolidating hospitals publicly tout the potential efficiency gains. But when responding to surveys, hospital executives are often skeptical about the benefits, and those executives who have been directly involved in consolidation are sometimes the most skeptical.[3] Several recent empirical studies of hospital systems and mergers have not fully answered the question of whether consolidation generates efficiencies.

Examining two different cross-sections (1988 and 1991), DSS compare the performance of thirteen local systems in California with the performance of "pseudosystems" – aggregations of independent hospitals matched to the actual systems. They find virtually no differences in either cross-section between actual and pseudo systems in terms of costs or offerings of high tech services. However, they find that actual systems had higher prices and higher profit margins.[4]

Connor and colleagues (CFD) study local hospital mergers across the entire United States over a period of nine years. They regress changes in average hospital costs and prices against a variety of predictors, including whether the hospital has recently merged. They find that hospitals that have recently merged experience smaller cost increases than those that have not. They also find that the magnitude of the cost increase depends on characteristics of the merging hospitals and their markets. For example, hospitals whose merger partners have many overlapping services tend to experience

[3] See Greene (1990, 1992) and Colon et al. (1999)

[4] Menke (1997) examines a cross-section of over 2000 hospitals in 1990 to determine whether hospitals in both local and national systems had lower costs than did independent hospitals. She finds that the typical system hospital had lower average costs than did the typical independent hospital, after controlling for case-mix, patient severity, and local wages. However, her findings are very sensitive to functional form.

slower relative cost increases than do hospitals whose merger partners have few overlapping services.

At first blush, the results of DSS and CFD seem to be in conflict. The former seems to find that consolidation does not reduce costs. The latter disagrees. However, there are two important differences in these studies that suggest that the results may not be inconsistent.

First, the two studies examine different forms of consolidation. When it comes to hospitals, mergers are not the same as systems, and we should not expect the same results. At first blush, it is somewhat difficult to distinguish mergers from systems. In both, independent hospitals combine under common ownership. Thus, both DSS consolidations and CFD consolidations would qualify as mergers in the general business literature. However, the term merger has a unique definition in health care. Hospital mergers involve the combination of separate facility licenses into a single license. Merged hospitals report a single set of financial and utilization statistics, and are regulated as a single entity (for example, for the purposes of certificate of need.)

Because of the financial reporting and regulatory implications, there may be important differences between mergers and systems. For example, consider independent hospitals wishing to shift inpatient services across facilities. By merging and effectively operating under a single license, hospitals may bypass a myriad of state regulations. Thus, we might expect that mergers would be associated with elimination of services, and therefore would generate larger savings. On the other hand, hospitals that do not intend to eliminate services may not find it necessary to merge. In the extreme, a merger may result in a hospital closure. This might lead to substantial cost savings, unless the patients and services are shifted to the surviving facility, and there is no reduction in fixed costs. In our empirical analysis, we distinguish among three forms of consolidation: systems, mergers, and mergers leading to closures.

A second critical difference between DSS and CFD is that the former perform cross-section studies, whereas the latter is a before-and-after study. This could explain the seemingly inconsistent results; for example, it could be that consolidating hospitals have above average costs prior to consolidation, and average costs afterwards. This suggests that both DSS and CFD could be marred by sample selection bias. The potential bias in DSS's cross-section study is readily apparent. Even though CFD use differenced data, it is not immune from bias either. CFD take differences over a nine-year period. Within a period of nine years many unobserved factors that are potentially correlated with the merger decision and costs may change, leading to bias in the estimate of the effect of merger, despite the use of differences. Furthermore, the effect is exasperated by the use of all other hospitals as a comparison group, as this admits a wide range of hospital sizes, locations, and case mixes as a comparison group to each merger.

In this paper, we perform a pre-post analysis using a common time period for all mergers. Like DSS, we randomly match hospitals with similar characteristics and create ten pseudo-mergers for the comparison group of each real merger. We choose our control group such that unmeasured shocks are expected to affect both merged and comparison hospitals similarly. Changes in costs are measured over a four-year period for all systems and mergers. Four-year differences allow us to control for more unmeasured heterogeneity than is possible when nine-year differences are used. However, it does imply that we will not capture long-term merger savings. We also control for mean regression. This is important, because all categories of mergers had higher than expected costs in the pre-merger period. Specifically, hospitals forming systems had costs that were 6.3% higher than predicted. Costs at merger/closure hospitals were 4.6% higher, and costs at merger/not closures were 5.9% higher.

3. Methods

We follow CFD and perform a pre-post study. To limit bias, we follow DSS and match each consolidating pair with a sample of "pseudo-consolidating" hospitals. The latter are drawn from the sample of all hospitals that do not undergo consolidation during the same time period when the consolidation occurred, and are matched for size, teaching status, case-mix, payor-mix and location. Consistent with previous studies of consolidations, including DSS, CFD, and Menke (1997), we estimate a cost function. We use a translog multi-product specification and control for hospital specific characteristics such as case-mix, patient mix, demographics, and ownership.

The log of total costs of hospital i in period t is modeled as follows:

$$\begin{aligned} \ln(c_{it}) = \alpha + \sum_m \alpha_m \ln(y_{mit}) + 0.5 * \sum_m \sum_n \beta_m \ln(y_{mit}) \ln(y_{nit}) + \alpha_w \ln(w_{it}) \\ + \beta_w \ln(w_{it}) \ln(w_{it}) + \sum_k \delta_k k_{kit} + \beta_\chi \chi_{it} + \lambda_i + \varepsilon_{it} \end{aligned} \quad (1)$$

where: y_{mit} is the output at hospital i in year m in category m (m = inpatient or outpatient); w_{it} is the average wage of hospital employees in the market served by hospital i in period t; k_{kit} indexes the type of merger (k=system, merger, merger/closure); χ_{it} is a vector of hospital market characteristics; λ_i is a hospital fixed effect; α, β, δ are parameters to be estimated; and ε_{it} is a normally distributed error.

Mean regression is often a problem in pre-post studies of hospital costs. Consider that there are often substantial fixed costs in the short run (Friedman and Pauly, 1981). Thus, a hospital that has a higher than expected patient census in one year will, as a result, enjoy lower than expected average costs that year. However, that hospital should expect an increase in average costs the next year, merely due to random fluctuations in volume. We follow Dranove and Cone (1985) to control for mean regression. In period 0 (pre-merger) hospital costs can be represented by the following equation

$$\begin{aligned}\ln(c_{i0}) &= \alpha + \sum_m \alpha_m \ln(y_{mi0}) + 0.5 * \sum_m \sum_n \beta_m \ln(y_{mi0}) \ln(y_{ni0}) + \alpha_w \ln(w_{i0}) \\ &+ \beta_w \ln(w_{i0}) \ln(w_{i0}) + \beta_\chi \chi_{0t} + \lambda_i + \varepsilon_{i0}.\end{aligned} \tag{2}$$

Similarly, period 1 (post-merger) hospital costs are

$$\begin{aligned}\ln(c_{i1}) &= \alpha + \sum_m \alpha_m \ln(y_{mi1}) + 0.5 * \sum_m \sum_n \beta_m \ln(y_{mi1}) \ln(y_{ni1}) + \alpha_w \ln(w_{i1}) \\ &+ \beta_w \ln(w_{i1}) \ln(w_{i1}) + \sum_k \delta_k k_{ki1} + \beta_\chi \chi_{i1} + \lambda_i + \varepsilon_{i1}.\end{aligned} \tag{3}$$

Mean regression implies the errors (i.e. unexplained cost components) are auto-correlated:

$$\varepsilon_{i1} = \gamma \varepsilon_{i0} + \mu_{i1}. \tag{4}$$

thus we can express the difference in costs as:

$$\begin{aligned}\ln(c_{i1}) - \ln(c_{i0}) &= \alpha + \sum_m \alpha_m \Delta \ln(y_{mi}) + 0.5 * \sum_m \sum_n \beta_m \Delta[\ln(y_{mi}) \ln(y_{ni})] \\ &+ \alpha_w \Delta \ln(w_i) + \beta_w \Delta[\ln(w_i) \ln(w_i)] + \sum_k \delta_k k_{ki} + \beta_\chi \Delta\chi_i + (\gamma - 1)\varepsilon_{i0} + \mu_{i1}.\end{aligned} \tag{5}$$

Equation (5) represents the key estimation equation in our analysis.

In addition to controlling for mean regression, we also must address the potential endogeneity of admissions, outpatient visits, HMO penetration as well the consolidation decision. Admissions and visits may be endogenous because insurers may funnel patients to low cost hospitals. HMO penetration may be endogenous because HMOs are likely to initially select high-cost markets to enter. Since these variables are correlated with the merger decision it is possible that failure to control for endogeneity could bias our results.

The correlation of the merger decision with unobservable variables can also potentially bias our results. For example, if merger are more likely to occur in markets where insurers are pressing for greater cost and/or price reductions, then we can potentially over-estimate the effect of mergers on lower costs. In other words, costs would trend lower at the hospital in the absence of the merger. Our goal in correcting for this type of correlation in the error is to test whether our results our robust.

We use standard two-stage least squares regression to control for endogeneity. The first-stage merger decision is estimated using a linear probability model since we are primarily interested in the effect of mergers on costs (See Heckman 1978. p. 947). We test the joint significance of the instruments in the first-stage and perform Basmann (1960) over-identification tests in order to confirm that the instruments are valid. Furthermore, as suggested in Staiger and Stock (1997), we report the version of the Durbin-Wu-Hausman test using the OLS estimate of the disturbance variance. All standard errors are calculated using robust variances (See Stata, 2001).

We check whether our results are robust to changes in the sample in several ways. First, we re-estimate Equation 5 using only one matched comparison pseudo-merger. We repeat this for each of the ten possible pseudo-mergers. We then calculate the number of times the resulting point estimate is within the 95% confidence interval of the estimate for the full sample. Next, because we excluded mergers that had less than ten matched comparison mergers in the main sample we estimate a sample with all possible mergers and up ten comparison pseudo-mergers. Thus, mergers with less than ten matched hospitals are also included in this sample. We also estimate the model without mergers where hospitals had the same name in the pre-period. These hospitals were not officially merged according to the AHA in pre-period, the official merger occurred one year later.

We also check whether our results are robust to change in the specification. We estimate the model without the quadratic and interaction terms on the inputs and output; we estimate an average cost version of Equation 5; include the base year Herfindahl; include the number of services duplicated in the base year; and we estimate the model with urban hospitals only.

We also test whether the cost changes associated with each merger type vary by pre-period market concentration; number of duplicated services[5]; and the year of the merger. We do this by interacting Herfindahl thresholds (<33 percentile and <66 percentile but >33 percentile) with the merger indicator variables. In a separate specification we interact the number of duplicated services with the merger indicator variables. We interact an indicator of whether the merger occurred before 1993 with the merger indicator variables. Finally, we estimated Equation 5 using a two, three, and four year follow-up period.

We adjust the estimates for smearing by calculating:

$$(E(Costs|\ k_{k\,post}) - E(Costs|\ k_{k\,post}= 0\ ))/\ E(Costs|\ Pre\ ). \qquad \textbf{(6)}$$

[5] The services are cat-scan, MRI, ultrasound, transplant, cardiac catheter lab, diagnostic radioisotope facility, extracorporeal shockwave lithotripter, open heart surgery, and radiation therapy.

Equation 6 is the percentage change in costs of the merger less the percentage change in costs had the merger not occurred. The smearing estimator is calculated using the un-differenced data by taking advantage of the fact that first-differences are equivalent to fixed effects. We conducted Breusch Pagan, Park, and Glejser tests and found no evidence of heteroscedasticity by merger type. However, there was evidence of heteroscedasticity by the other independent variables. We bootstrapped the estimates 500 times to obtain the confidence intervals.

4. Data

The primary dataset is the American Hospital Association's (AHA) Annual Survey of Hospitals (1988-1998) supplemented by financial information from the Medicare Cost Report. We use the Medicare Cost Report in place of the AHA Annual Survey when there was no response in the AHA's Annual Survey. The dataset also includes demographic information from the Area Resource File (ARF) and HMO penetration data corrected for the 'home office' reporting problem in the ARF.[6] We created the analysis dataset as follows.

First, we restrict attention to combinations of two independent hospitals into a single merged entity or system. We begin by identifying all one-to-one mergers and system consolidations consummated between 1989 and 1997. This represents our sample of consolidating hospitals. To form a comparison group, we match nonconsolidating hospitals (which include independent hospitals as well as hospitals that may have consolidated prior to 1988) to consolidating hospitals, based on the following characteristics:

[6] This refers to the fact that HMO enrollment data reported in the ARF is based on the location of the HMO's home office, rather than the location of the enrollees. We thank Douglas Wholey for making these data available.

-- Total hospital beds (plus or minus 25%)

-- Location (urban-rural)

-- MSA size (plus or minus one of six size categories)

-- Teaching status

-- Ownership

-- Presence of a skilled nursing unit;

-- Medicaid share (plus or minus 25 percentages points)

-- Medicare share (plus or minus 25 percentages points).

Next, we created pseudo-consolidations among the matched comparison hospitals and randomly drew up to ten pseudo consolidations for every actual consolidation. We limited the sample to those hospitals that reported complete cost and utilization data to the AHA or the Medicare cost report one year before and two years after the consolidation. There were 112 consolidations of 224 hospitals that had complete data and were matched to at least ten pseudo-consolidations with complete data. We also estimate the model using a sample that includes consolidations with less then ten comparison combinations. In this larger sample there are 130 consolidations of 260 hospitals.

In the sample with the three and four year follow-up period we used the same matched comparison group. However, in many of the cases either one of the matched hospitals or the merged hospitals did not report data in one of the latter years. In fact, only 58 of the matched groups had complete data two, three, and four years following merger. Thus we present results that reflect this limited group of hospitals in addition to a sample that includes all possible mergers and matches separately.

It is important to distinguish between mergers in which both facilities remain open and mergers in which one facility subsequently closes or convert to another use. The latter may generate substantially greater cost reductions as allocated fixed costs (and, potentially, some variable costs) are eliminated. To identify closures, we examined the listing of addresses contained in the AHA Directory of hospitals.[7] In most cases following a merger, the directory lists the addresses of both facilities. We treat these as cases in which both facilities remain open. In 16.1 percent of the cases for which we had complete data, the directory no longer lists the address of one of the facilities. We treat this as a closure. We confirmed the identity of closures by examining the hospital's web site or contacting them by phone. In a little more than half of the cases, one of the buildings was converted to medical-related use that was not inpatient hospital care, in the remaining cases one of the buildings was no longer being used for healthcare related purposes. In addition to identifying consolidation status, we include several control variables in our estimation of equation (5). These are listed in Table 1.

We use three types of instruments in our analysis. First, we use characteristics of the market that are likely to be correlated with the instrumented variable (i.e. inpatient admissions, outpatient visits, HMO penetration, and merger decision) but not directly correlated with costs. These are number of beds per square mile, population, and population greater than 65. We expect these variables to effect hospital level cost only through right-hand side variables. The second type of instrument is the characteristics of other hospitals in the market. These are number of hospital and long-term care admissions of other hospitals, number of outpatient visits to other hospitals, number of

[7] We could rule out the possibility of consolidations leading to closure because in such an event, the closed hospital would no longer exist in the data.

general and long-term beds at other hospitals, number of general and long-term FTEs at other hospitals, share of Medicaid and Medicare revenues at other hospitals, and average number of high-tech services at other hospitals. The third type of instrument is state regulations regarding certificate of need. We include a 0-1 dummy to indicate whether the state had CON regulations in 1992 and a variable that represents the number of services subject to CON.

Results

Table 2 reports summary statistics for our data. The data are broken down into three sets of columns. The first set reports pre- and post-merger summary statistics for the actual consolidating hospitals. The last column in the first set reports the difference between the pre- and post-merger values. For example, total operating costs increase by an average of 7.6 percent post merger. The second set repeats the same information for the pseudo-merger matching hospitals. For these hospitals, costs increased by an average 8.8 percent. The last set contains one column with the difference in differences. Continuing our example, this column shows that costs increased more in the comparison group, though the difference is not statistically significant at $p < .05$.

There are number of other noteworthy facts in Table 2. The number of outpatient visits rises significantly more rapidly among the comparison hospitals. At the same time, the number of beds falls more rapidly among the actual merger hospitals. Furthermore, the number of high-tech services and the number of skilled nursing facilities increase more rapidly at merged hospitals.

Table 3 reports the base differences and the difference in differences by merger type. There is no significant difference between system acquisition and the matched comparison mergers. The increase in cost per bed, cost per FTE, number of high-tech services, Medicare case-mix, and number of skilled nursing units was greater than the comparison group at mergers that did not result in closure. However, the number of beds decreased by a greater amount at mergers that did not result in closure. Changes in costs, cost per admission, the number of outpatient visits, and the number of beds were significantly less than the comparison group at mergers then closures. However, there was a greater increase in the number of high-tech services and skilled nursing units at these facilities.

Table 4 present the specification tests from the first-stage of the two stage least squares regressions. Overall, the instruments do a fairly good job of explaining the variation of the instrumented variable, the F-test of the significance of the instruments is greater than 3 in eight of nine regressions and the R-squared is greater than 0.20 in seven of nine regressions. The major exception is system acquisitions, where the F-test for the significance of the instruments is only 1.88. The R-squared in this regression is also relatively low at 0.12.

Our key findings appear in Table 5, which presents several specifications of the cost regressions. Robust standard errors appear in parentheses. Results in column (1) suggest that systems and mergers without closures neither increase nor decrease costs, whereas merger/closures lead to substantial cost decreases. However, these results do not account for mean regression, which models (2) through (5) show is quite important. The coefficients on the mean regression parameter indicate that a hospital that had ten percent higher costs than predicted in the pre-merger period would experience a four percent reduction in costs due solely to mean reversion. This is important, because all categories of mergers had higher than expected costs in the pre-merger period. Thus, if we fail to account for mean regression, we might mistakenly attribute the resulting cost reductions to merger efficiencies.

Columns (2) through (5) present our findings corrected for mean regression. Columns (2) and (3) do not control for endogeneity of admissions or mergers; column (3) differs from column (2) because it includes fixed effects for each actual merger/pseudo merger combination. Both specifications show that mergers without closures are associated with an approximately 4 to 5 percent increase in costs. Mergers/closures are associated with an approximately 5 to 6 percent decrease in costs. System appears to have no effect on costs. These results change only slightly when we control for endogeneity, as seen in columns (4) and (5). The point estimates do not change dramatically but the standard error on the merger then closure variable increase so that the estimate is not significant.

Coefficients on control variables are generally in line with expectations. Increases in wages, Medicare and Medicaid shares, surgery rates, teaching status, and local income are usually associated with higher costs. Increases in percentage births and HMO penetration are associated with lower costs.

Table 6 shows the results when we re-estimate the model by comparing each consolidation with each possible pseudo-consolidation. We find that at least 90% of the one-to-one estimates fall within the 95% confidence interval of the estimate based on the full sample. However, the individual significance of the estimates of the one-to-one sample is not always consistent. In the specification controlling for regression to the mean, but without merger group fixed effects, 60 percent of the runs yield significant and positive cost effect for mergers without closure, while 70 percent of the runs yield significant and negative cost effects for mergers with closure. The results for the sample with merger group fixed effects reveal that only 40 percent of the mergers without closure estimates imply increased cost, while 40 percent of the merger with closure estimates imply decreased cost.

The results of the alternative specifications are in Table 7. The results are consistent across most of the specifications. The parameter associated with mergers without closures is insignificant only when we exclude quadratic and interaction terms of the outputs and inputs. The parameter associated with mergers then closures loses significance when we look at urban hospitals only.

Table 8 displays the results of the interactions of the merger variables and base-line characteristics. The only significant interaction is the merger without closure variable and the HHI 33rd percentile indicator and the HHI 66th percentile indicator. Both imply that cost increases are greater in more competitive markets. The results also suggest that earlier consolidations fared better than later ones, but none of the interactions are significant at conventional levels.

The results with the three and four year follow-up period are in Table 9. The first set of three columns report the results from a balanced panel of hospitals. All merger types are associated with a reduction in costs in the third and fourth year. However, only the Merger/Closure coefficients are statistically significant. The second set of columns report the results from a sample of all observations, including consolidations with less than ten matched pseudo mergers. The results are quite similar to the first set, except that the Merger/No closure coefficients are closer to significance. The results smearing-adjusted results are in Table 10. Only the Merger/Closure estimates are statistically significant in all three follow-up periods.

Discussion

We set out to update and reconcile the seemingly conflicting literature on hospital consolidation, by using consistent data and methods and correcting for several potential sources of bias. Our findings are compatible with DSS, who fail to find any savings associated with consolidation. However, our findings using a two-year follow-up stand in contrast with CFD, who documented substantial merger savings. However, our findings using three and four year follow-up reveal significant savings for mergers then closures, and smaller (and insignificant) savings for other types of consolidation.

We can identify several reasons why our results on mergers differ from those of CFD. First, we separate merger/closures from other mergers. The former are associated with substantial savings, and help improve the apparent performance of the average merger. Second, we examine more recent data. CFD found that later mergers generated smaller efficiencies than did mergers in the 1980s, so our results may be an extension of this trend. Third, we examine one-to-one mergers, whereas CFD study all mergers, even those involving the acquisition of a single hospital by a large system. We believe that ours is a cleaner approach, as we would not expect the same benefits on a per-hospital basis when a large system acquires a single hospital.

There are also important methodological differences between our work and that of CFD. We compare consolidating hospitals with only carefully selected matching pseudo-consolidations, thereby limiting potential endogeneity bias. We estimate a translog cost function, which may do a better job of controlling for changes in patient load and patient mix. We study a consistent time window from one year prior to two years post merger. CFD examine a nine-year period without regard for when hospitals merged within that period. While our window admittedly limits us to finding short term merger effects, the CFD window seems *ad hoc*. While their window enables them to capture long run cost reductions at hospitals that merged early on, it also counts as merger savings any cost reductions realized prior to merger by hospitals that did not merge until the end of their window.

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Table 1: List of Variables, Definitions, and Sources

Variable	Definition	Source
Hospital Costs	Real total operating expense	AHA Annual Survey
Inpatient admissions	Total inpatient admissions	AHA Annual Survey
Outpatient admissions	Total outpatient visits (including ER)	AHA Annual Survey
Wages	Real average hospital wage in the market	AHA Annual Survey
Medicaid share	Medicaid share of total discharges	AHA Annual Survey
Medicare share	Medicare share of total discharges	AHA Annual Survey
Percent births	Births as a percent of total admissions	AHA Annual Survey
Percent ER	ER visits as percent of total outpatient visits	AHA Annual Survey
Percent LTC	Skilled nursing admissions as a percent of total inpatient admissions	AHA Annual Survey
Percent OPT surgery	Outpatient surgeries divided by outpatient visits	AHA Annual Survey
Percent IPT surgery	Inpatient surgeries divided by inpatient admissions	AHA Annual Survey
Case-mix index	Medicare cost report index	Medicare Cost Report
Teaching	Presence of a residency program	AHA Annual Survey
Non-federal government		AHA Annual Survey
For-profit		AHA Annual Survey
HMO Penetration	Percent HMO enrollees in market	ARF, corrected for 'home office' reporting
Population density	Persons per square mile	ARF
Per capita income		ARF
Mean regression measure	Residual from cross-section estimate of costs	Estimated

Table 2. Summary Statistics

	Mergers			Comparison			Difference in Differences
	Pre	Post	Difference	Pre	Post	Difference	
Total Operating Costs ($1000s)	1211.770	1303.856	92.086	1087.196	1183.094	95.898*	-3.812
	(1355.006)	(1431.014)		(1121.157)	(1235.252)		
Cost per Bed	2.254	2.659	0.406*	2.116	2.396	0.280**	0.125**
	(1.010)	(1.167)		(0.802)	(0.903)		
Cost per FTE	0.560	0.598	0.038*	0.542	0.562	0.019**	0.019
	(0.122)	(0.142)		(0.133)	(0.108)		
Cost per Admission	6.431	7.039	0.607*	6.021	6.589	0.568	0.039
	(2.103)	(2.123)		(1.867)	(1.750)		
Number of Inpatient Admissions (100s)	165.805	166.026	0.221	164.259	165.601	1.343	-1.121
	(127.631)	(133.404)		(123.063)	(129.214)		
Number of Outpatient Visits (100s)	1818.366	2000.131	181.765	1835.320	2215.504	380.184**	-198.419*
	(1583.778)	(1776.796)		(1527.398)	(1845.283)		
Number of FTEs	1981.946	2040.821	58.875	1876.299	1976.423	100.124	-41.249
	(1808.574)	(1874.010)		(1672.930)	(1821.428)		
Number of Beds	458.688	423.679	-35.009	451.982	437.122	-14.860	-20.149**
	(308.862)	(290.721)		(309.053)	(295.599)		
HMO penetration rate	0.132	0.173	0.042*	0.137	0.183	0.046**	-0.005
	(0.128)	(0.150)		(0.110)	(0.131)		
Number of High Tech Services	5.696	5.9375	0.241	5.551	5.745	0.194*	-0.047
	(1.847)	(2.276)		(1.704)	(1.720)		
Market Hospital Wage (Logged)	236.716	244.740	8.024	236.846	245.469	8.623**	-0.599
	(41.833)	(43.821)		(38.202)	(39.371)		
Medicaid Share of Inpatient Days	0.144	0.154	0.011	0.151	0.162	0.012*	-0.001
	(0.101)	(0.098)		(0.119)	(0.123)		
Medicare Share of Inpatient Days	0.492	0.508	0.016	0.488	0.505	0.017**	-0.001
	(0.120)	(0.122)		(0.121)	(0.131)		
Percent of Births	0.113	0.110	-0.003	0.117	0.115	-0.001	-0.002
	(0.059)	(0.058)		(0.053)	(0.053)		

Notes: ** Significant at 1% Level ; * Significant at 5% Level.

Table 2. Summary Statistics (continued)

	Mergers			Comparison			Difference in Differences
	Pre	Post	Difference	Pre	Post	Difference	
Percent ER Admissions	0.312	0.283	-0.029	0.309	0.273	-0.037**	0.007
	(0.144)	(0.151)		(0.127)	(0.119)		
Percent SNF Admissions	0.010	0.017	0.007*	0.008	0.014	0.006**	0.001
	(0.018)	(0.026)		(0.016)	(0.022)		
Outpatient Surgeries/Visits	0.043	0.044	0.001	0.041	0.039	-0.002*	0.003
	(0.022)	(0.025)		(0.024)	(0.022)		
Inpatient Surgeries/Admits	0.321	0.298	-0.022	0.325	0.312	-0.013**	-0.010
	(0.089)	(0.095)		(0.099)	(0.096)		
Medicare Case-mix	1.342	1.585	0.243	1.320	1.364	0.044**	0.200**
	(0.189)	(1.832)		(0.189)	(0.206)		
Teaching Hospital	0.344	0.353	0.009	0.315	0.322	0.008	0.002
	(0.423)	(0.465)		(0.413)	(0.412)		
Non-federal Government Hospital	0.127	0.131	0.004	0.137	0.140	0.003	0.001
	(0.306)	(0.319)		(0.316)	(0.313)		
For-Profit Hospital	0.104	0.151	0.047	0.096	0.101	0.004	0.043**
	(0.260)	(0.354)		(0.247)	(0.250)		
Separate Skilled Nursing Facility	0.229	0.392	0.163**	0.227	0.312	0.085**	0.078**
	(0.346)	(0.457)		(0.328)	(0.360)		
Population Density	531.104	537.878	6.774	612.229	620.221	7.992	-1.218
	(1023.506)	(1032.582)		(1034.023)	(1044.308)		

Notes: ** Significant at 1% Level ; * Significant at 5% Level. Standard Deviations in parentheses

Table 3. Summary Statistics by Merger Type

Variable	System Acquisitions			Mergers/No Closure			Mergers/ Closures		
	Difference	Comparison Difference	Difference in Difference	Difference	Comparison Difference	Difference in Difference	Difference	Comparison Difference	Difference in Difference
Total Operating Costs ($1000s)	72.390	102.535	-30.146	139.107	88.816	50.291	17.036	97.819	-80.784
Cost per Bed	0.256	0.259	-0.004	0.609*	0.266	0.343**	0.247	0.371	- 0.124
Cost per FTE	0.024	0.015	0.009	0.059*	0.018	0.0415**	0.021	0.034	- 0.013
Cost per Admission	0.701*	0.649	.052	0.704	0.484	0.220	0.108	0.585	- 0.477
Number of Inpatient Admissions (100s)	-1.765	-0.039	- 1.73	2.908	2.601	0.307	-1.866	1.516	- 3.381
Number of Outpatient Visits (100s)	116.263	252.062	- 135.798	296.175	480.228	- 184.054	44.068	440.823	- 396.755*
Number of FTEs	122.479	128.387	- 5.909	41.062	82.021	- 40.958	-56.166	76.172	- 132.339*
Number of Beds	-21.565	-12.754	- 8.811	-43.813	-14.375	- 29.437*	-45.889	-21.533	- 24.356
HMO Penetration rate	0.026	0.041	- .0145	0.059	0.049	0.0113	0.034	0.043	- 0.009
Number of High Tech Services	0.347	0.228	0.120	0.167	0.133	0.033	0.167	0.267	-0.100
Market Hospital Wage (Logged)	0.032	0.034	- 0.002	0.035	0.029	0.007	0.026	0.063	-0.038
Medicaid Share of Inpatient Days	0.019	0.014	0.004	-0.005	0.010	- 0.015	0.032	0.009	0.023
Medicare Share of Inpatient Days	0.013	0.026	- 0.013	0.023	0.006	0.017	0.003	0.022	-0.019

Notes: ** Significant at 1% Level ; * Significant at 5% Level.

Table 3. Summary Statistics by Merger Type (continued)

Variable	System Acquisitions			Mergers/No Closure			Mergers/Closures		
	Difference	Comparison Difference	Difference in Difference	Difference	Comparison Difference	Difference in Difference	Difference	Comparison Difference	Difference in Difference
Percent of Births	-0.003	-0.002	-0.001	-0.005	-0.002	- 0.003	0.002	0.000	0.001
Percent ER Admissions	-0.022	-0.030	0.008	-0.044	-0.043	- 0.001	-0.011	-0.039	0.028
Percent SNF Admissions	0.009**	0.005	0.004	0.004	0.006	- 0.003	0.012	0.005	0.007
Outpatient Surgeries/Visits	0.001	-0.001	0.001	0.000	-0.004	0.004	0.000	-0.004	0.007
Inpatient Surgeries/Admits	-0.006	-0.014	0.008	-0.033	-0.014	- 0.018	-0.037	-0.006	-0.031
Medicare Case-mix	0.066	0.044	0.015	0.491	0.040	0.481*	0.036	0.035	0.029
Teaching Hospital	0.003	0.007	0.004	0.021	0.014	0.060	-0.008	0.014	0.014
Non-federal Government Hospital	0.013	0.001	0.010	-0.004	0.003	- 0.003	0.000	0.000	0
For-Profit Hospital	0.099	0.004	0.083	0.011	0.003	- 0.003	0.013	-0.006	0.006
Separate Skilled Nursing Facility	0.127	0.064	0.055	0.151*	0.082	0.084	0.285	0.072	0.206**
Population Density	11.307	10.071	1.366	-4.261	8.805	- 13.066*	6.951	7.495	-0.544
Number of Mergers	46	460		48	480		18	180	

Notes: ** Significant at 1% Level ; * Significant at 5% Level.

Table 4. Specification Tests

	First-stage F Test	First-stage R2
Inpatient Admissions	3.18	0.29
Inpatient Admissions, Squared	3.21	0.30
Outpatient Admissions	10.00	0.71
Outpatient Admissions, Squared	9.22	0.71
Inpatient*Outpatient	7.54	0.60
HMO Penetration	3.35	0.35
System Acquisition	1.88	0.12
Merger/ Not close	20.97	0.32
Merger / Close	7.81	0.19

Table 5. Cost Function

	OLS (1)	OLS with Year 1 Residual (2)	OLS with FE (3)	2SLS (Outputs and HMO Pen) (4)	2SLS (Outputs, HMO Pen, and Merger) (5)
Constant	0.111***	0.107***	0.113***	0.137***	0.125***
	(0.012)	(0.012)	(0.030)	(0.040)	(0.043)
Merger Variables					
System Acquisition	0.006	0.028	0.021	0.014	0.102
	(0.020)	(0.022)	(0.021)	(0.022)	(0.144)
Merger/ No closure	0.016	0.041**	0.047**	0.060**	0.033
	(0.018)	(0.019)	(0.018)	(0.025)	(0.060)
Merger/ Closure	-0.079***	-0.059**	-0.066**	-0.063	-0.083
	(0.026)	(0.028)	(0.030)	(0.041)	(0.145)
Outputs					
Inpatient Admissions	-0.605*	-0.559*	-0.283	0.397	0.833
	(0.310)	(0.324)	(0.342)	(1.716)	(1.703)
Outpatient Admissions	0.418	0.338	0.020	-0.793	-0.832
	(0.263)	(0.205)	(0.191)	(1.062)	(0.980)
Inpatient Admissions, Squared	0.055***	0.067***	0.055***	0.089	0.063
	(0.018)	(0.019)	(0.019)	(0.151)	(0.136)
Outpatient Admissions, Squared	-0.014	-0.001	0.010	0.072	0.075
	(0.018)	(0.014)	(0.013)	(0.072)	(0.059)
Inpatient*Outpatient	-0.003	-0.024	-0.020	-0.099	-0.101
	(0.024)	(0.022)	(0.021)	(0.180)	(0.147)
Hospital Characteristics					
Wage	-0.495	0.554	2.453*	2.235	2.877
	(1.305)	(1.213)	(1.345)	(1.698)	(1.882)
Wage, Squared	0.068	-0.025	-0.210*	-0.190	-0.249
	(0.119)	(0.111)	(0.123)	(0.155)	(0.172)
Medicaid Share	0.124**	0.162***	0.125**	0.115	0.123
	(0.058)	(0.057)	(0.052)	(0.084)	(0.085)
Medicare Share	0.262***	0.220***	0.152**	0.181**	0.188**
	(0.060)	(0.051)	(0.059)	(0.077)	(0.073)
Percent Births	-0.370**	-0.352***	-0.267**	-0.076	-0.129
	(0.180)	(0.130)	(0.129)	(0.268)	(0.277)
Percent ER	-0.006	0.031	-0.017	-0.189	-0.192
	(0.092)	(0.070)	(0.065)	(0.324)	(0.301)
Percent LTC	0.144	0.127	0.486*	0.324	0.348
	(0.278)	(0.267)	(0.274)	(0.336)	(0.339)
Percent Outpatient surgery	0.460	0.537*	0.096	-0.457	-0.434
	(0.397)	(0.324)	(0.322)	(1.084)	(1.046)
Percent Inpatient surgery	0.058	0.085**	0.091**	0.166**	0.143*
	(0.040)	(0.039)	(0.040)	(0.084)	(0.083)
Case-mix index	0.001	0.001	0.004	0.007	0.007
	(0.003)	(0.004)	(0.004)	(0.008)	(0.008)
Teaching Hospital	0.007	0.014	0.048***	0.048**	0.050**
(Continued on next page)	(0.018)	(0.017)	(0.017)	(0.023)	(0.022)

Notes: *** Significant at 1% Level ; ** Significant at 5% Level; * Significant at 10% Level.
Robust standard errors in parentheses

Table 5. Cost Function (Continued)

	OLS	OLS with Year 1 Residual	OLS with FE	2SLS (Outputs and HMO Pen)	2SLS (Outputs, HMO Pen, and Merger)
Hospital Characteristics (continued)					
Non-federal Gov Hospital	-0.050	0.000	0.029	0.040	0.033
	(0.055)	(0.056)	(0.051)	(0.091)	(0.097)
For-profit Hospital	-0.092*	-0.080	-0.066	-0.047	-0.083
	(0.054)	(0.053)	(0.059)	(0.064)	(0.089)
Market Characteristics					
HMO Penetration	-0.096**	-0.076*	-0.019	-0.874**	-0.679*
	(0.046)	(0.045)	(0.047)	(0.359)	(0.382)
Population Density	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Per Capita Income	0.000***	0.000***	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Regresion to the mean control					
Period 1 residual	N/A	-0.398***	-0.400***	-0.403***	-0.407***
		(0.079)	(0.059)	(0.063)	(0.062)
P-value for over-identification test				0.667	0.741
P-value for Durban-Wu-Hausman test				~1.00	~1.00
Merger/Control Combination Dummies			Yes	Yes	Yes

Notes: *** Significant at 1% Level ; ** Significant at 5% Level; * Significant at 10% Level.
Robust standard errors in parentheses

Table 6. Results of sample with one merger and one pseudo-merger control

	Percent within 95% C.I. For Full Sample	Significant and Positive Effect (5% Level)	Significant and Negative Effect (5% Level)
Specification 2: Without Merger/Comparison Dummies			
System	10/10	0/10	0/10
Merger/No closure	10/10	6/10	0/10
Merger/ Closure	10/10	0/10	7/10
Specification 3: With Merger/Comparison Dummies			
System	10/10	0/10	0/10
Merger/No closure	9/10	4/10	1/10
Merger/ Closure	9/10	0/10	4/10

Table 7. Alternative Specifications

	1	2	3	4	5	6	7
System	0.008	0.021	-0.014	0.018	0.020	0.019	0.030
	(0.019)	(0.021)	(0.018)	(0.021)	(0.021)	(0.021)	(0.024)
Merger/No closure	0.049**	0.061***	0.026	0.049**	0.048***	0.046**	0.067***
	(0.019)	(0.021)	(0.018)	(0.019)	(0.019)	(0.018)	(0.024)
Merger/ Closure	-0.089***	-0.051*	-0.108***	-0.065**	-0.065**	-0.067**	-0.065
	(0.028)	(0.029)	(0.027)	(0.029)	(0.030)	(0.030)	(0.046)

1) Sample with all mergers and pseudo mergers
2) Sample excluding mergers where the hospital had the same name in the pre-period
3) Excluding quadratic and interacted outputs
4) Average cost function
5) Including base year Herfindahl
6) Including base year service duplication
7) Urban only

Notes: *** Significant at 1% Level ; ** Significant at 5% Level; * Significant at 10% Level.
Robust standard errors in parentheses

Table 8. Specifications with interactions

	Base	Interacted w/ HHI<=33rd Percentile	Interacted w/ HHI<=66th Percentile	Joint Significance (p-value)
System	-0.017	0.035	0.066	0.546
	(0.030)	(0.037)	(0.053)	
Merger/No closure	-0.009	0.082*	0.077**	0.0291
	(0.021)	(0.045)	(0.035)	
Merger/ Closure	-0.047	-0.034	-0.011	0.1273
	(0.056)	(0.067)	(0.083)	
HHI<=33rd Percentile	-0.030**			
	(0.015)			
HHI<=66rd Percentile	-0.029***			
	(0.011)			
	Base	Interacted w/ Duplicate Services	Joint Significance (p-value)	
System	0.005	0.005	0.5716	
	(0.040)	(0.011)		
Merger/No closure	0.029	0.005	0.0419	
	(0.030)	(0.008)		
Merger/ Closure	-0.082	0.005	0.0558	
	(0.078)	(0.027)		
Number of Duplicate Services	-0.002			
	(0.003)			
	Base	Interacted with Merger Before 1993	Joint Significance (p-value)	
System	0.033	-0.021	0.5931	
	(0.037)	(0.042)		
Merger/No closure	0.053**	-0.021	0.0377	
	(0.023)	(0.035)		
Merger/ Closure	-0.036	-0.058	0.0446	
	(0.042)	(0.057)		
Merger before 1993	0.072			
	(0.048)			

Note: Three separate specifications; Standard Errors in parenthesis
Notes: *** Significant at 1% Level ; ** Significant at 5% Level; * Significant at 10% Level.
Robust standard errors in parentheses

Table 9. Sample with a 2, 3, and 4 year follow-up period

	Balanced			Unbalanced		
	2 year	3 year	4 year	2 year	3 year	4 year
System	0.001	-0.008	-0.020	0.008	-0.015	-0.033
	(0.017)	(0.023)	(0.028)	(0.019)	(0.025)	(0.030)
Merger/No closure	0.051	-0.048	-0.050	0.049**	-0.052	-0.048
	(0.025)	(0.034)	(0.041)	(0.019)	(0.043)	(0.037)
Merger/ Closure	-0.083**	-0.119***	-0.102***	-0.089***	-0.151***	-0.149***
	(0.036)	(0.038)	(0.032)	(0.028)	(0.030)	(0.032)
N		638		2226	1818	1354

Unbalanced sample includes mergers with less than 10 matches
Specification: OLS w/ FE and Regression to the mean.
Notes: *** Significant at 1% Level; ** Significant at 5% Level; * Significant at 10% Level.
Robust standard errors in parentheses

Table 10. Results Adjusted for Smearing

	2 year	3 year	4 year
System	0.018	-0.014	-0.031
	(-0.02, 0.06)	(-0.07, 0.04)	(-0.10, 0.04)
Merger/No closure	0.035	-0.061	-0.057
	(-0.01, 0.08)	(-0.15, 0.03)	(-0.13, 0.02)
Merger/ Closure	-0.089	-0.155	-0.158
	(-0.14, -0.03)	(-0.21, -0.08)	(-0.23, -0.09)

Sample includes mergers with less than 10 matches
Specification: OLS w/FE and regression to the mean.
95% confidence intervals in parentheses from bootstrap (500 iter.)